

TECHNICAL MEMORANDUMS  
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

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No. 226

ABSORBING LANDING SHOCKS.

By Edward P. Warner,  
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ABSORBING LANDING SHOCKS.\*

By Edward P. Warner.

The necessary strength of an airplane structure depends largely on the force of the blow which has to be transmitted through the body and wings when the wheels strike the ground. That blow, in turn, is governed in part by the skill of the pilot and in part by the design of the landing gear, for no pilot, however skilled, could land without unpleasant impact on a rigid landing gear incorporating no device for shock absorption. Some of the early airplanes, to be sure, had no shock absorbers except their tires, and those were of small section and inefficient for the purpose, but the airplane of 1910 was expected to land only on a specially prepared surface.

The type of wheel and tire now used on airplanes, although it is not expected to absorb the entire landing impact, has high efficiency as a spring. The early wheels were much like those used on bicycles in construction and even in dimensions, but they are now made much stouter, with hubs of exceptional length to keep the rim from being swept off sidewise in a landing across the wind. The tires are made of much lighter section than are the standard type of automobile tires, the weight thus being reduced and the flexibility of the casing increased. The diameter of the tire section itself is from one-quarter to one-sixth of the outside diameter of

\* Taken from Christian Science Monitor.

the wheel on an airplane, while the corresponding ratio for motor vehicles travelling on the earth's surface is from one-seventh to one-tenth. The dimensions, 36 by 8 and 44 by 10, for example, are common airplane tire sizes. Finally, airplane tires are inflated to relatively low pressure, in order that the yield on striking the ground may be large and the springing effect a maximum. Curiously enough, automobile practice now seems to be turning in a direction where it was anticipated by ten years by the designer of aircraft, for the very latest and most revolutionary of developments in automobile tires includes the light casing construction, the large tire section over a relatively small rim diameter, and the low operating pressures which have long been familiar to the aeronautical engineer.

near.

#### The Dual Function of Tires.

The tires, like every other element of the shock-absorbing system, have a dual function. They act as springs, to let the airplane down gently by allowing its gradual retardation to continue for some appreciable time instead of coming with a sudden bang when the airplane first strikes, as would necessarily be the case if the landing mechanism were entirely rigid. Furthermore, they must act as true shock absorbers, using up energy through friction or otherwise and so checking the rebound. In an automobile the two functions are generally separated as far as practicable and performed by different groups of members, but in an airplane they are almost always combined. A tire, which makes an excellent spring, is a very poor shock-absorber. It must be supplemented from some other sources,

for if all the springing were obtained from very large and flabby tires the airplane would be liable to bounce into the air again after striking the ground, exactly as an automobile may bounce if the springs are too lively.

The commonest supplement for the tires is a rubber shock-absorber, made up of a great number of long thin strands enclosed in a covering of elastic braid, so forming a single cable about the thickness of a man's forefinger. Such a cable is wound many times around two pins, one carried by the axle close to the wheel, and the other connected to the permanently rigid part of the landing gear structure. On striking the ground the axle is thus able to rise, yielding to the shock, but the movement is partially restrained by the stretching of the rubber cord as the two pins separate.

#### Steel Springs Unpopular.

Steel springs have occasionally been used in place of rubber, but have met with little favor except in Germany during the war, when the rubber shortage necessitated the substitution of other material. Steel is very unsatisfactory as a true shock-absorber, as the internal friction between the particles is far less than in rubber, where the sliding of the individual strands over each other as the cord elongates uses up a large part of the tendency of the stretched cord to produce rebound. The energy which might go to raise the airplane promptly into the air again after its first contact with the ground is converted into friction instead, and thence

is finally dissipated in the form of heat, producing an infinitesimal rise in the temperature of the air surrounding the rubber. There is another reason, however, much more important than this, for the unpopularity of steel. It is actually inferior to rubber in efficiency as a spring, comparing the two materials on the basis of equal weights. Were it not for its rapid deterioration and its extreme sensitiveness to weather conditions, which disqualify it, rubber would undoubtedly replace metal in the springs of road vehicles wherever weight was considered to be of importance.

The comparative efficiencies of rubber and steel can best be illustrated by giving specific figures for a particular case. It would require a steel spring weighing 30 pounds to bring to rest, without damage to the spring itself, a 1000-pound weight dropped from a height of three feet. With rubber, however, only two pounds of the material would be needed for the same purpose.

#### The Oleo Gear.

Another possibility is the use of a hydraulic type of shock absorber, such as is sometimes employed to resist the rebound of the springs on automobiles. Such a shock absorber, more commonly referred to simply as an oleo gear when used in connection with airplanes, consists of an oil-filled cylinder in which a piston moves. The piston is pierced by a number of small holes, allowing the oil to flow from side to side, but offering considerable resistance to its rapid passage. When the wheels strike the ground the motion of the axle forces the piston upward in the cylinder, and the oil, resisting its

motion, exerts an approximately constant force directly opposed to the movement of the axle and corresponding to the force that would be applied by a rubber shock absorber if one were used. In addition to the holes drilled through the piston, a valve held shut by a spring is generally used to keep the resisting force more nearly constant than it would be if the oil could only flow through holes of constant size, and to keep the oil pressure from rising to so high a figure in a bad landing that it would be likely to burst the cylinder.

When the oleo gear is used it must be supplemented by a light spring to return the piston to the bottom of the cylinder, as the shock absorber itself would have no tendency to return to its original condition. The combination of spring and oleo gear can usually be made to weigh less than a spring alone, and there seems to be no doubt that the present arrangement of rubber cord will, at least on large airplanes, where the saving in weight more than counterbalances the disadvantage of the increased complexity of the mechanism, ultimately be superseded by something in the nature of a hydraulic device. The life of the landing gear will be lengthened and its weight reduced.

#### Travel of the Axle.

The actual force of the impact of the airplane against the ground, a very important matter from the point of view of the designer, is dependent on the type of shock absorber, on the sort of landing made, and on the distance through which the axis is allowed to

travel. The last of these items is of great importance. Obviously, it takes more actual force to bring an airplane to rest in three inches of vertical movement than in three times that distance. Airplanes to be flown by unskilled pilots, then, or those which are liable to have to make forced landings at night or on bad fields, should have allowance for ample travel of the axle, in order that the impact loads, in landing, may not be large enough to cause the landing gear or body structure to fail. Even a very bad landing can be made with safety if the landing gear was designed for rough treatment. In fact, it is possible, by using shock absorbers with sufficient vertical yield, to produce an airplane which can be flown straight into the ground on its normal angle of descent, no flattening of the path before contact being necessary. In this connection, again, the oleo gear presents distinct advantages. It is easy to design a cylinder in which a piston will travel for 15 inches or more, but an arrangement of rubber cord becomes rather bulky and awkward when an attempt is made to allow for such large vertical movements. When rubber is depended on, the effective travel of the axis is seldom more than seven inches at most.

Shock-absorbing mechanisms can, in general, be said to be very effective at present. There will undoubtedly be further improvements, however, and they should be directed primarily toward the use of some material more durable than rubber and toward the development of devices which will reduce the piloting skill required to make a satisfactorily smooth landing under adverse conditions.